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Abstract: The paper established a new sealed bargaining mechanism based on the electronic business negotiation model and considering the opaqueness of information on demand and supply. Using the supply function and demand function to analyze the behavior rule during the course of the price change, in the paper we established and proved a series of intersecting chord theorems about concave supply function and demand function, thus we got a transaction mechanism of negotiating prices that manufacturers and distributors submitted the supply and demand according to node gradually recursion algorithm after the first offer made by the e-commerce platform, And proved the negotiated price converged to the equilibrium price of supply and marketing.

Keywords: Bargaining Mechanism，Negotiated Pricing，Node Gradually Recursion Algorithm

1. INTRODUCTION

As a kind of interactive two-way communication channel, network bridges the communication gap between the subjects in the market, and realizes trade negotiation and trading activities under different asynchrony with low transaction cost. The development of electronic commerce makes bargaining mechanism innovation, especially the loose group which the supply chain consists of a plurality of enterprises, hope that negotiate on trade through the electronic commercial platform, in order to identify common transaction price and the respective number. Recently, some electronic commercial platform which started to launch shopping assistant or shopping agency with some negotiation functions[9] , which puts forward a new problem to the research of pricing mechanism.

From researches on pricing model under electronic commerce we can see, most of scholars quoted the manufacturer's learning mechanism to solve it. Gupta et al. (2002) established a Dutch auction model based on network environment, using the Markov decision process model, and Q - learning algorithm, only the price game situation is discussed[1]. Carvalhbo et al. (2003) using Kalman filtering method, gives a heuristic algorithm to guide the future pricing with previous transaction information, which cannot adjust the current pricing timely[2]

Raju et al. (2005) consider monopoly electronic retailer's pricing and inventory problems, price are made by the seller, the buyer obtain products according to the bid price level[3]; There are also some other scholars study online reverse auction problem[4][5], they believe that online reverse auction is becoming a new vitality way to trade, with the rising status of buyer (including individual, organization or enterprise) ,the buyers is gradually playing a leading role in trade. Tang Qiusheng etc. (2012) established MeRCRM quantity discount game model based on the theory of Stackelberg, which achieved the purpose to improve the sales and the manufacturer, retailer's income[6]; Based on data driven, He Zhigan etc. (2011) set model view controler (MVC) as the basic framework, presented a new price pricing model on online shopping mall which describe reference price trend chart very well[7].

These studies have rarely considered that under the electronic commerce environment, trade state changed by both common decision-making behavior is a game between buyer and seller matchmaking transaction. The traditional auction theory mainly for a fixed quantity of auction through the auction price formation, which is usually high value and less number items, the affect of auction transaction volume is less considered[8]. But for the large scale supply or demand problem of many manufacturers or distributors, it needs to consider the relationship between trading volume and price.

This paper studies the manufacturers and dealers in the product transaction, both sides under the incomplete information game environment make t their initial price and quantity to maximize their individual interests, and repeated comparison together in the third party trading system based on the sealed private valuation, and finally form a transaction price and transaction volume.

2. MODEL ANALYSIS AND ASSUMPTIONS

Because of the random factors and incomplete information transparency, from the consumer market to the dealer, and then to the manufacturers, the information from demand information transfer to order information, and then form to supply information, there is bullwhip effect of supply and demand, so both sides in the transfer price determined and the corresponding quantity could not coordinated, performance on a transfer price, it existences quantitative differences in optimal product identified by both sides, both parties to determine the optimal product quantity differences according to the minimum quantity, the minimum number of transactions is not able to achieve the maximum benefits of the whole supply chain. So in the supply chain alliance, the leading party or third party determine the optimal market sales and initial transfer price according to the maximum benefits of the whole supply chain , under the electronic commerce environment, it is very easy to implement alliance member according to the transfer price and order quantity, a closed price negotiation will be carry out in the electronic commerce platform, then form a new price and feedback to all members, all members submit new quantity according to the new price and benefit maximization, like this repeated negotiation ,finally realize interest distribution mechanism, and this price reflects interest distribution mechanism and relationship in the alliance. This transaction mechanism is similar to the trading agent with negotiation function mentioned in Strbel Michael (2000)[9], the core problem is the design of interest distribution mechanism, so that the sealed price matchmaking platform can reflect the characteristics and requirements of the sale of both buyers and sellers, realize the price and quantity both sides can accept. This paper holds that the bargaining ability of both buyers and sellers and their respective demand or supply elasticity related.

Hypothesis

1) many manufacturers in auction platform are regarded as a whole, the same to dealers, that is, only one manufacturer and one distributor, both sides need to clinch a deal;

2) the relative elasticity greater, the advantage of interests distribution more;

3) Both manufacturers and dealers determine their optimal quantity based on profit maximization;

4) manufacturers understand their supply function, and dealers know demand function, both buyers and sellers know their own elastic but do not know each other's;

5) As the auction platform ,the third party can learn characteristics of supply function and demand function on a certain degree through the relationship between the declared price and quantity after displaying price of both sides;

6) Dealers purchase cycle is fixed constant T, manufacturers forecast production and delivery in $[0,K]$

according to predict situation based on $x(t)=\frac{k_2}{4k_1}t^2+\frac{4k_1Q^*-k_2K^2}{4k_1K}t$, $0\le t\le K$ [10], dealers and manufacturers make a auction match on day K, after closing the auction , the manufacturer can complement the parts beyond expected. Because of the distribution process, the commodity will be served at the end of day T-K.

3. SET NEGOTIATED PRICING MODEL

The paper established a new negotiation model and algorithm in electronic business environment, to realize the supply and demand sides submit product quantity according to the price, and adjust the price further until it reaches the bargain transaction requirement.

3.1 Gradually node recurrence Negotiated principle.

Facing a market price, whether manufacturer or dealer will determine supply and demand according to maximize their own interests, that is, the supply function and demand function decided their response to price. In order to describe the reaction condition, this paper use supply function and demand function to analyze both sides behavior under the variable price.

3.1.1 Negotiated Pricing of linear demand and supply.

First assume that demand and supply curve are linear, the third party e-commerce platform gives the product polling price, later become display price, due to the linear demand and supply, need only two times submitted quantity according to price ,we can determine the linear demand function and supply function in the electronic commerce platform:

The demand curve: $$Q=D(p)=\frac{D_2p_1-D_1p_2}{p_1-p_2}-\frac{D_2-D_1}{p_1-p_2}p \tag{1}$$

The supply curve: $$Q=D(p)=\frac{D_2p_1-D_1p_2}{p_1-p_2}-\frac{D_2-D_1}{p_1-p_2}p \tag{2}$$

By $D(p)=S(p)$, we get the coordinates of the intersection, i.e. the equilibrium price and equilibrium quantity (Figure 1):

$$p^*=\frac{(D_2-S_2)p_1-(D_1-S_1)p_2}{(D_2-D_1)-(S_2-S_1)} \tag{3}$$

$$Q^*=\frac{D_2S_1-D_1S_2}{(D_2-D_1)-(S_2-S_1)} \tag{4}$$

3.1.2 Negotiated Pricing of nonlinear demand and supply.

This section study on nonlinear and concave demand and supply curve, assume that demand function monotone reduced and concave, that is, $D'(Q)<0$ and $D''(Q)>0$; Supply function monotone increasing and concave, that is $S'(Q)>0$ 且 $S''(Q)>0$. At this time, the line which connect any two points on each given curve is no longer a demand or supply function, and the node is not equilibrium price and quantity, but but pay attention to two points line is the string of a concave function, we can establish a series of theorems and corollaries as follows.

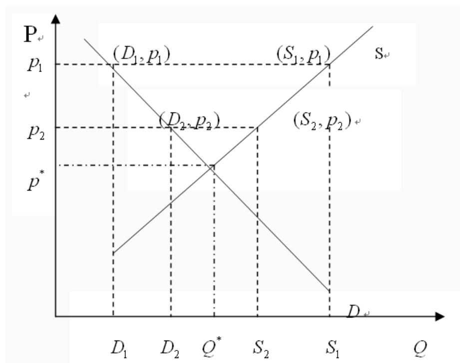

Figure 1 Negotiated Pricing of linear curve

Theorem 1: If two intersected line are the chord of two concave functions concave, and the slope of the lines is non zero, then the crossover point of the concave function is below the crossover point of their chord.

Proof: From the concave function definition we know, the function value of any point on the curve is less than the function value of any point on the chord, that is, concave function curve is below its chord. Given line segments $l_1: y=\alpha_1+\beta_1 x$, ($\beta_1>0$, $x\in[a,b]$) and $l_2: y=\alpha_2+\beta_2 x$, ($\beta_2<0$, $x\in[a,b]$) were chords of monotone reduced and concave function $y=f(x), x\in[a,b]$ and monotone increasing and concave function $y=g(x), x\in[a,b]$, as shown in figure 2,two lines intersect to point *N* and curves intersect to point *M*.

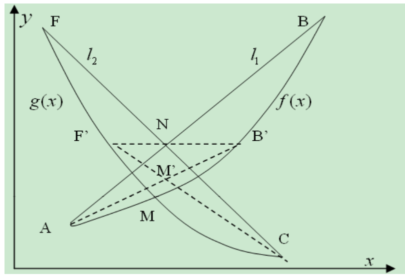

Figure 2. concave functions & their intersection chords

For $\forall x\in[a,b]$, we get $f(x)<\alpha_1+\beta_1 x$ and $g(x)<\alpha_2+\beta_2 x$, and curve intersection point $M(x_M, y_M)$ meet function $y=f(x)$ and $y=g(x)$, then, $y_M<\alpha_1+\beta_1 x_M$ and $y_M<\alpha_2+\beta_2 x_M$, and point *M* must be below common line l_1, l_2.

Definition 1 (Cross Intersection Point Chord) Given two concave or convex function intersect at the point $M(x_0, y_0)$, linear l_1 intersect with curve $y=f(x)$ at two points respectively $A(x_1, y_1)$, $B(x_2, y_2)$, linear l_2 intersect with $y=g(x)$ at two points $C(x_3, y_3)$, $F(x_4, y_4)$, if $x_1< x_0<x_2$, then the line segment *AB* is cross intersection point chord of $f(x)$ relative to $g(x)$, if $x_3> x_0>x_4$, then the line segment *CF* is cross intersection point chord of $g(x)$ relative to $f(x)$.

Corollary 1 The crossover point of two cross intersection point chord is above intersection concave function.

Proof From theorem 1 we know crossover point N of two cross intersection point chord is above the concave function crossover point M, if N in the left lower side of $g(x)$, then the chord CF in near N and below $g(x)$, which is contradict to concave function definition, in like manner, N will not in the lower right side of $f(x)$.

Theorem 2 The horizontal cross intersection point chord of intersection concave function intersect with $f(x)$ and $g(x)$ at B' and F' respectively, then AB' and CF' are still the cross intersection point chord of $f(x)$ and $g(x)$, the crossover point is above the two concave function and below AB and CF.

Proof set the coordinates of B' and F' are $B'(x_2', y_k)$ and $F'(x_4', y_k)$, from Theorem 2, we get $y_k>y_0$, again, $f(x)$ is increasing function and $g(x)$ is reduce function, we reach $x_1<x_0<x_2'$ and $x_3>x_0>x_4'$, by definition 1, we know AB' and CF' are still the cross intersection point chord of $f(x)$ and $g(x)$.

From Theorem 2, we get AB' and CF' intersect at M', M' is above the two concave function.

Line AB' is below AB, M' is on AB',then, M' must be below AB; Line CF' is below CF, M' is on CF',then, M' must be below CF,so M' is below common AB and CF. Theorem proved.

If repeat operation according to theorem 2, we will get infinite pair of cross intersection point chord, and their crossover point is below the last crossover point and above $f(x)$ and $g(x)$, the collaring quadrilateral formed by $f(x)$, $g(x)$ and cross intersection point chord become more and more small, the outside diameter tending to 0, thus, we reach the corollary as follows:

Corollary 2 AB_k and CF_k are cross intersection point chords that intersecting concave functions $f(x)$ and $g(x)$ generate after k times generation by the way of Theorem 2, and M_k (x_k, y_k) is the intersection point. AB_{k+1} and CF_{k+1}, whose intersection point is M_{k+1} (x_{k+1}, y_{k+1}), is the cross intersection point chords of $f(x)$ and

$g(x)$ after k+1 times generation, $M(x_0, y_0)$is the intersection point of $f(x)$ and $g(x)$, and the point range $M_k(x_k, y_k)$ ($k = 1, 2, 3, ...$) will converge to $M(x_0, y_0)$.

So by inference we can get a most useful way of automatic bargaining, by which the difficulty of making a price resulted from incomplete information can be avoided, and transaction behavior of repeated bargaining on the internet can be easily realized.

Usually, the price demand function $p = D(Q)$ and the price supply function $p = S(Q)$ are concave functions, by which they can be taken as $f(x)$ and $g(x)$ in the former theorem deduction. Suppose that both sides of the participants are not clear about the response mode of his trade counterpart, and they know nothing about the counterpart's demand or supply function, in which condition equilibrium can be got only by repeated tests. Line AB and CD could be taken as the lines connecting the two points which are formed separately on demand function and supply function after offering price (twice) on the auction platform. $M(Q^*, p^*)$ shows the market's equilibrium number and price, which also means the objective number and price of the bargained transactions. $M_k(Q_k,p_k)$is the match point of price bargaining after k times of offering prices on the auction platform and submitting available trade numbers. To get the point $M_k(Q_k,p_k)$, firstly, get 2 points which represent (k-2)th and (k-1)th match prices and submitted numbers on supply function, and connect these 2 points; secondly, get another 2 points which represent (k-2)th and (k-1)th match prices and submitted numbers on demand function, and connect these 2 points; the intersection point of these 2 connecting lines is $M_k(Q_k,p_k)$. Among which k=3，4，5…, the 1st and 2nd displayed prices and submitting numbers are chords' end points of explorative demand function and supply function

1). The condition when the equilibrium price is between the initial prices p_1 and p_2

Just as Theorem 2, under the condition when the initial prices p_1 and p_2 are located at each side of the equilibrium price, the connecting line of the two demand points and connecting line of the two supply points both are cross intersection point chords. Suppose that the kth and (k+1)th prices and numbers offered by the manufacturers and distributors are separately the end points' coordinate values on cross intersection point chords C_kF_k and A_kB_k of the demand and supply curves (see figure 3), then the ordinate value of M_{k+2}, which is the intersection point of the intersecting chords C_kF_k and A_kB_k, is the kth match price p_{k+2} (i.e., the (k+2) th reported price in the price series) . With this price, suppliers and buyers submit the demand number D_{k+2} and supply number S_{k+2} according to their own demand function or supply function, which represent as point $F_{k+2}(D_{k+2},p_{k+2})$ on the demand curve and point B_{k+2} (S_{k+2}, p_{k+2}) on the supply curve. So then the new intersecting chords C_kF_{k+1} and A_kB_{k+1} are got, whose intersection point is the next match point $M_{k+3}(Q_{k+3},p_{k+3})$. Through Theorem 2, series $\{M_k(Q_k, p_k), k=3,4,5…\}$will converge to market's equilibrium point $M(Q^*, p^*)$, and the match price p_k converges to p^*, submitting number Q_k converges to Q^*. In the actual execution, the match is successful only if the difference of demand and supply of the kth price offering $|S_k-D_k|$ is

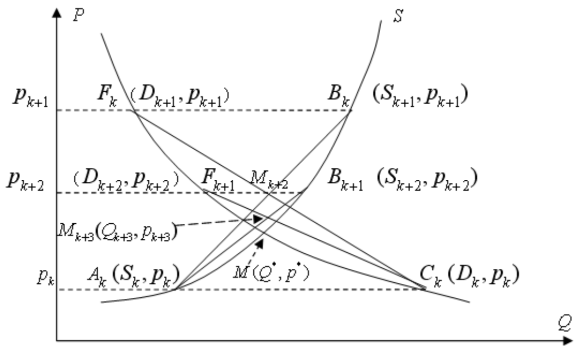

Figure 3. Schematic diagram of negotiated pricing if p^* is between the p_1 and p_2

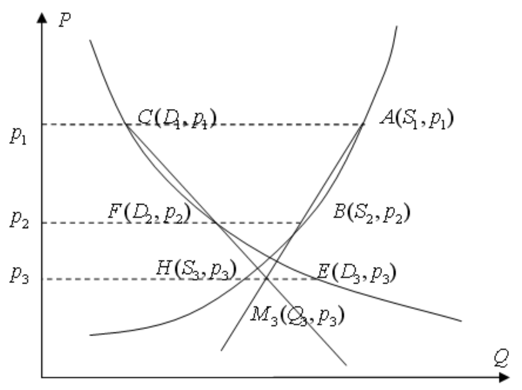

Figure 4. Schematic diagram of negotiated pricing if $p_1 > p_2 > p^*$

less than some set value.

2). The initial prices p_1 and p_2 are located above the equilibrium price

In this case, $p_1>p_2>p^*$. After the display of the initial price series p_1,p_2, the manufacturers and distributors submitted orderly the trade numbers they want according to these prices , therefore, the demand points A,B and supply points C,F on prices p_1,p_2 all are above equilibrium point M(see figure 4). The intersection point $M_3(Q_3,p_3)$ of the line AB and CF is the point on which makes a price match, that must be below the point M, supply curve S and demand curve D . The price p_3 was the first match price, according that the manufacturers and distributors submitted the new trade numbers and form new demand point E and supply point H, then, the lines EF and HB formed the cross intersection point chords, so situation 2 changed to situation 1.

3). The condition when the initial prices p_1 and p_2 are located below the equilibrium price

In this case, $p_1<p_2<p^*$. After the display of the initial price series p_1,p_2, the manufacturers and distributors submit orderly the available trade numbers, and therefore the demand points A,B and supply points C,F on prices p_1,p_2 are all below equilibrium point M(see figure 5). The intersection point M_3 of the line AB and CF is the point on which a price match is made, must be below the point M supply curve S and demand curve D, and the first match price $p_3\in(p_2, p^*)$ is made above the horizontal line $p=p_2$. According to the price p_3, the manufacturers and distributors submit the available trade numbers to make the new demand point E and new supply point H, and the line EF connecting the demand points and line HB connecting the supply points are in accordance with AB and CF. The line EF and HB intersects on $M_4(Q_4, p_4)$, and obviously there is a second match price $p_4\in(p_3, p^*)$. Repeat the above work, we can get the displayed price series $\{p_k\}$(k=3,4,5…) which converges to p^*.

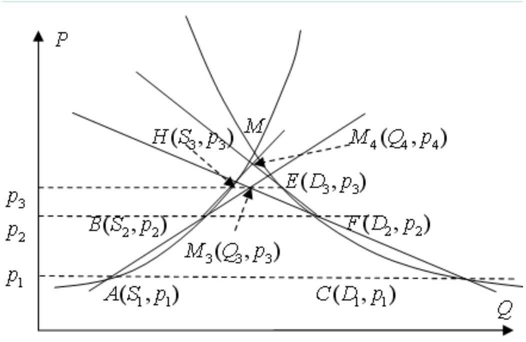

Figure 5. Schematic diagram of negotiated pricing if $p_1<p_2<p^*$

Under these three conditions above, the displayed price series $\{p_k\}$(k=3,4,5…) are all convergent resembling convergence of Newton tangent method. Newton tangent method utilizes tangents and axis to form recursive points, and converges fast. This paper utilizes chord intersection to form recursive points, with which method it converges to the same order. Given the rather complex cost-benefit analysis during the companies' matching process, the times of price matching must be reduced. The basic rules are that under the condition when the demand differs considerably from the supply after the price is displayed for the first time, and the distance between second displayed price and the first displayed price should be sufficient, not be too small or too big. When the distance satisfies $|p_2-p_1|<|p^*-p_1|$, the larger the distance is, the faster the convergence speed will be. Such as in figure 5, the intersection point $M_3(Q_3, p_3)$ mounts at an accelerating rate when the dotted line $p=p_2$ translates upwards; when the distance is too large that $|p_2-p_1|>|p^*-p_1|$, the condition of negotiated pricing changes into the condition when first equilibrium price is located between the initial prices p_1 and p_2. Under this condition, the convergence speed will get slower as the distance gets larger, but the reducing process is decelerated and has no impact on convergence.

3.2 Node Gradually Recursion Algorithm.

According to the principle of price match, whether the initial price is in the 1st condition, or 2nd condition and 3rd condition is judged by whether the positive or negative sign of the 2 difference between supply and demand are the same, i.e., $(D_1-S_1)(D_2-S_2)<0$ is the 1st condition, otherwise is the 2nd or 3rd condition. Further, if $D_1<S_1$, it is the 2nd condition; if $D_1>S_1$, it is the 3rd condition. Besides, the expressions of condition 2 and condition 3 during the variables' recursive transformation are the same, so the divergent selection of judgment can be used to solve the problem of different initial prices.

This paper provides the node gradually recursion algorithm:

Step1. Displayed price on e-commerce platform p_1, the manufacturers and distributors submit available trade numbers S_1, D_1.

Step2. If $|S_1 - D_1| < \varepsilon$ (ε is the difference between supply and demand amounts), the matchmaking succeeds, and then exit the cycle and execute step 9.

Step3. According to the difference of S_1, D_1, the platform displayed the second price p_2 (if $S_1 > D_1$, then $p_2 < p_1$,otherwise $p_2 > p_1$), and the manufacturers and distributors submit available trade numbers S_2, D_2.

Step4. If $|S_2 - D_2| < \varepsilon$, the matchmaking succeeds, and then exit the cycle and execute step 9.

Step5. According to the 2nd expression, calculate the bargaining price $p_3 = \dfrac{(D_2 - S_2)p_1 - (D_1 - S_1)p_2}{(D_2 - D_1) - (S_2 - S_1)}$

Step6. As to the displayed price p_3, the manufacturers and distributors again submit available trade numbers S_3, D_3.

Step7. If $|S_3 - D_3| < \varepsilon$, the matchmaking succeeds, and then exit the cycle and execute step 9.

Step8. If $(D_1 - S_1)(D_2 - S_2) < 0$, let $p_2 = \min(p_1, p_2)$, $S_2 = \min(S_1, S_2)$, $D_2 = \max(D_1, D_2)$, $p_1 = p_3$, $D_1 = D_3$, $S_1 = S_3$, then turn to step 5; otherwise, if$(D_1 - S_1)(D_2 - S_2) > 0$, let $p_1 = p_2$, $D_1 = D_2$, $S_1 = S_2$; $p_2 = p_3$, $D_2 = D_3$, $S_2 = S_3$, then turn to step 5.

Step9. Output the bargaining price p^* (the final displayed price on the platform) and bargaining amount Q^*, if there is only p_1 in the price series, then $p^* = p_1$, $Q^* = (D_1 + S_1)/2$; if there are only p_1 and p_2 in the price series, then $p^* = p_2$, $Q^* = (D_2 S_1 - D_1 S_2) / [(D_2 - D_1) - (S_2 - S_1)]$; if there are p_1, p_2 and p_3 in the price series, then $p^* = p_3$, $Q^* = (D_2 S_1 - D_1 S_2) / [(D_2 - D_1) - (S_2 - S_1)]$.

4. CONCLUSIONS

This paper proved related theorems about intersecting chords, especially the theorem that the recursive process of intersecting chords which cross the intersection will finally converge to intersection of curves. It also provides theoretical support for the convergence of price match, and thus it can be confirmed that concave supply function and demand function could close a deal according to node gradually recursion algorithm. Besides, as the recursive process of intersecting chords which cross the intersection is high order convergence, there generally would be relatively rare times of price match before equilibrium, and both sides of the transaction would be liable to accept and glad to participate in quoting price. Moreover, this algorithm is of benefit for controlling cost of e-commerce platform, and it is of good practicability.

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